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(71) Applicant: NIPPON CHEMICAL INDUSTRIAL  
COMPANY LIMITED  
Tokyo 136-8515 (JP)

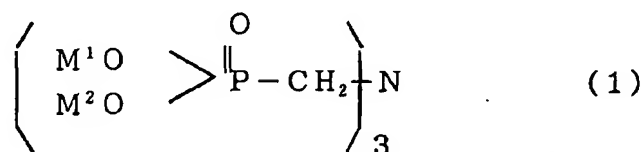
(72) Inventors:  
• HARA, Yoshifusa, Nippon Chem. Ind. Co., Ltd.  
Tokyo 136-8515 (JP)

• TAMURA, Ken, Nippon Chem. Ind. Co., Ltd.  
Tokyo 136-8515 (JP)  
• NISHIMURA, Takashi,  
Nippon Chem. Ind. Co., Ltd.  
Tokyo 136-8515 (JP)  
• MATSUMOTO, Nobuo,  
Nippon Chem. Ind. Co., Ltd.  
Tokyo 136-8515 (JP)

(74) Representative: HOFFMANN - EITLE  
Patent- und Rechtsanwälte  
Arabellastrasse 4  
81925 München (DE)

(54) **FLAME RETARDANT COMPOSITION AND FLAME-RETARDANT RESIN COMPOSITION**

(57) A flame retardant composition containing a nitrilotris(methylene)phosphonic acid metallic salt produced by reacting nitrilotris(methylene)phosphonic acid represented by the following general formula (1) and a salt thereof with a divalent metallic compound is provided.



(wherein M<sup>1</sup> and M<sup>2</sup> represent a hydrogen atom or an alkaline-earth metal) The composition according to the present invention has smoke suppression properties, emits no irritating odor, and can impart superior flame retardancy to various resins while maintaining the inherent mechanical properties of the resins.

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## Description

## Technical Field

**[0001]** The present invention relates to a non-halogen base flame retardant composition and a flame-retardant resin composition having smoke suppression properties, emits no irritating odor, and is able to impart superior flame retardancy to various resins while maintaining a inherent mechanical properties of the resins.

## Background Art

**[0002]** As flame retardants for plastics, halides of chlorine, bromine, etc., phosphorus base compounds, nitrogen base compounds, or antimony and boron based inorganic compounds have been used.

**[0003]** In recent years, however, the levels of flame retardancy required have become stricter in every field, and high flame retardancy has being demanded. In particular, since it was pointed out that flame retardants containing bromine or chlorine have the possibility of generating dioxins in very small amounts which are still poisonous to humans during combustion, the need for non-halogen base flame retardants has intensified.

**[0004]** As non-halogen base flame retardants, regarding a thermosetting resin for example, a resin composition, in which red phosphorus is blended, (Japanese Patent Publication No. 59-49942), hydrated alumina (Japanese Patent Application Laid-open No. 05-25369), surface treated red phosphorus, hydrated alumina, silica powder (Japanese Application Laid-open No. 58-198521), and reformed red phosphorus (Japanese Patent Application Laid-open No. 63-156860) as a flame retardant for an epoxy resin, calcium borate and aluminum hydroxide or magnesium hydroxide (Japanese Patent Application Laid-open No. 05-43774) for a phenol resin, boric acid and antimony dioxide (Japanese Patent Application Laid-open No. 60-81244) for a phenol resin, and a compound having three triazine structures in a molecule (Japanese Patent Application Laid-open No. 53-21241) for a polyurethane resin, have been proposed.

**[0005]** On the other hand, regarding a thermoplastic resin, flame retardants, for example, magnesium hydroxide (Japanese Patent Application Laid-open No. 54-83952 and Japanese Patent Application Laid-open No. 54-131645) and melamine cyanurate (Japanese Patent Application Laid-open No. 53-31759 and Japanese Patent Application Laid-open No. 54-91558) for a polyamide resin, an organic sulfonate (Japanese Patent Application Laid-open No. 50-98539 and Japanese Patent Application Laid-open No. 50-98540) and sulfimide acid salt (Japanese Patent Application Laid-open No. 01-22304) for a poly carbonate resin, a phosphonate compound and ammonium polyphosphate (Japanese Patent Application Laid-open No. 52-86449) and a phosphate compound and antimony trioxide (Japanese Patent Application Laid-open No. 49-32947) for polyphenylene oxide, and polyphosphonate (US Patent No. 3719727) for a polyester, have been proposed.

**[0006]** Since red phosphorus is, however, reddish brown, resins are colored by red phosphorus so that coloring is impossible. Furthermore, working environments become worse due to generation of phosphine gas during thermal processing and incineration of resins. In order to suppress this, for example, red phosphorus is covered with a covering agent, but the generation of phosphine gas cannot be completely prevented.

**[0007]** In other flame retardants, it is also difficult to impart superior flame retardancy to various resins without degrading color tones, mechanical properties of the resins, and there are problems of smoke and irritating odor generation during combustion.

**[0008]** Organic phosphorus base flame retardants are particularly notable as non-halogen base flame retardants. The mechanism of its flame retardation is that in high volatile flame retardants, thermally vaporized phosphorus compounds retard combustion of plastics as flame retardants in gas phase by an effect of diluting gaseous oxygen, an effect of cooling combustion system due to vaporization, and an effect of suppressing chemical reactions of combustion, etc. On the other hand, in less volatile flame retardants, phosphoric acid is produced by thermal cracking due to heating, and this becomes metaphosphoric acid and polymetaphosphoric acid so as to form a nonvolatile phosphoric acid polymer on a surface of a solid phase or fused layer of the burning plastic. In addition, the plastic is carbonized by the dehydration reaction of phosphoric acid so as to form a carbonized layer to thereby cut off the access of air, and the supply of external thermal energy so as to retard combustion.

**[0009]** Hitherto, as organic phosphorus base flame retardants, various kinds of phosphoric esters and phosphite bases have been proposed, but most of those compounds are, watersoluble so as to have low affinity with resins. Furthermore, since those compounds have low phosphorus content, in order to increase the flame retardant effect, resins must contain large amounts of those compounds so that mechanical properties are degraded.

**[0010]** Nitrilotris(methylene)phosphonic acid and derivatives thereof are used in various areas as scale inhibitors, anticorrosives, metallic surface treating agents, and chelating agents. In Japanese Application Laid-open No. 05-4997, it is disclosed that nitrilotris(methylene)phosphonic acid 6 melamine salt is superior flame-retardant compound. The resins, in which the aforementioned compound is blended as a flame retardant, exhibit some flame retarding effect, but there are drawbacks in that the flame retarding effects are still insufficient in practice, and furthermore, mechanical

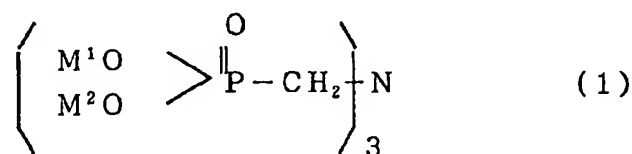
properties of the resin are degraded.

[0011] In consideration of the aforementioned problems, the inventors of the present invention earnestly investigated non-halogen base flame retardants and as a result, noted nitrilotris(methylene)phosphonic acid that has a high phosphorus content, and discovered that a divalent metallic salt of the aforementioned compound could impart superior flame retardancy to various resins without degrading mechanical properties so as to complete the present invention.

[0012] That is, objects of the present invention are to provide a non-halogen base flame retardant composition which can impart superior flame retardancy to various resins without degrading mechanical properties, and to provide a resin composition having superior flame retardancy.

#### Disclosure of Invention

[0013] The present invention aims to provide a flame retardant composition characterized by containing a nitrilotris(methylene)phosphonic acid metallic salt produced by reacting nitrilotris(methylene)phosphonic acid represented by the following general formula (1):



(wherein  $M^1$  and  $M^2$  represent a hydrogen atom or an alkaline-earth metal) or a salt thereof with a divalent metallic compound.

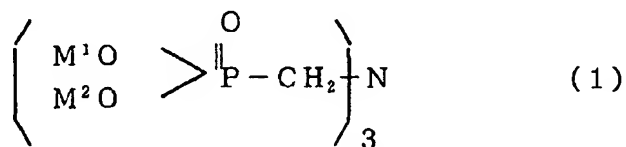
[0014] A flame retardant composition according to the present invention is preferably a composition containing the aforementioned nitrilotris(methylene)phosphonic acid metallic salt and a hydrated metallic compound, or is preferably a composition containing the aforementioned nitrilotris(methylene)phosphonic acid metallic salt, the hydrated metallic compound, and furthermore, a phosphorus base flame retardant as a flame-retardant assistant.

[0015] The present invention also aims to provide a flame-retardant resin composition constitutionally characterized in containing a resin and the aforementioned flame retardant composition.

#### Best Mode for Carrying Out the Invention

[0016] The present invention will be explained below in detail.

[0017] A flame retardant composition according to the present invention contains a nitrilotris(methylene)phosphonic acid metallic salt produced by reacting nitrilotris(methylene)phosphonic acid represented by the following general formula (1):



(wherein  $M$  and  $M^2$  represent a hydrogen atom or an alkaline-earth metal) and a salt thereof with a divalent metallic compound.

[0018] In the general formula (1),  $M$  and  $M^2$  represent a hydrogen atom or an alkaline-earth metal. As the alkaline-earth metal, Li, Na, and K are preferable.

[0019] A method for producing the nitrilotris(methylene)-phosphonic acid metallic salt by reacting nitrilotris(methylene)phosphonic acid represented by the aforementioned general formula (1) and a salt thereof with the divalent metallic compound is not specifically limited, and publicly known methods can be used. For example, it may be performed by a method of reacting nitrilotris(methylene)phosphonic acid represented by the aforementioned general formula (1) and a salt thereof with the divalent metallic compound in water, a mixed solvent of water-acetone, or an aqueous solvent of water-alcohol, etc.

[0020] As the divalent metallic compound, oxyacid salts, hydroxides, oxides, halides, etc., of divalent metals are listed. As the oxyacid salt of the divalent metal, sulfates, carbonates, phosphates, nitrates, nitrites, etc., are listed. As the divalent metal, for example, Mg, Ca, Ba, Sr, and Zn are listed.

[0021] In the reaction for producing the nitrilotris(methylene)phosphonic acid metallic salt which is an objective of the aforementioned reaction, the ratio of nitrilotris(methylene)phosphonic acid represented by the general formula (1) and a salt thereof to a divalent metal, which are raw materials, is usually in the range of 1 to 3 moles of the divalent metal relative to 1 mole of nitrilotris(methylene)phosphonic acid represented by the general formula (1) and a salt thereof. The amount of divalent metal compound used is appropriately controlled based on the amount of the divalent metal to be introduced into the objective within the aforementioned range.

[0022] The nitrilotris(methylene)phosphonic acid metallic salt produced by the reaction may be either an anhydride or a hydrate, in the present invention, however, the hydrate is preferably used.

[0023] As specific examples, nitrilotris(methylene)phosphonic acid-magnesium salt, nitrilotris(methylene)phosphonic acid-2 magnesium salt, nitrilotris(methylene)phosphonic acid-3 magnesium salt, nitrilotris(methylene)phosphonic acid-calcium salt, nitrilotris(methylene)phosphonic acid-2 calcium salt, nitrilotris(methylene)phosphonic acid-3 calcium salt, nitrilotris(methylene)phosphonic acid-barium salt, nitrilotris(methylene)phosphonic acid-2 barium salt, nitrilotris(methylene)phosphonic acid-3 barium salt, nitrilotris(methylene)phosphonic acid-strontium salt, nitrilotris(methylene)phosphonic acid-2 strontium salt, nitrilotris(methylene)phosphonic acid-3 strontium salt, nitrilotris(methylene)phosphonic acid-zinc salt, nitrilotris(methylene)phosphonic acid-2 zinc salt, and nitrilotris(methylene)phosphonic acid-3 zinc salt, etc., are listed. At least one of these compounds is used.

[0024] In the flame retardant composition according to the present invention, flame retarding effects can be further increased by concurrent use of a hydrated metallic compound. As the hydrated metallic compound, compounds having a flame retarding function due to endothermic reactions, represented by  $M_mO_n \cdot XH_2O$  (M represents a metal, m and n represent an integer of at least 1 determined based on the valence of the metal, and X represents contained water of crystallization), or double salts containing the aforementioned compound, specifically, at least one kind selected from the group consisting of aluminium hydroxide, magnesium hydroxide, basic magnesium carbonate, calcium hydroxide, barium hydroxide, zirconium hydroxide, dawsonite, zinc stannate, zinc borate, aluminum borate, antimony pentaoxide, basic zinc carbonate, cobalt oxide, zirconium oxide, tin oxide, aluminum oxide, titanium oxide, magnesium oxide, calcium silicate, borax, zinc molybdate, zinc phosphate, magnesium phosphate, hydrotalcite, hydrocalumite, kaolin, talc, sericite, pyrophyllite, bentonite, kaolinite, calcium sulfate, zinc sulfate, etc., are listed. These hydrated metallic compounds may be surface treated.

[0025] Blending ratio of the hydrated metallic compound is usually 1 to 200 parts by weight, preferably 10 to 100 parts by weight relative to 100 parts by weight of nitrilotris(methylene)phosphonic acid metallic salt.

[0026] Furthermore, in the flame retardant composition according to the present invention, a flame-retardant assistant can be concurrently used. As the flame-retardant assistant, for example, at least one kind selected from the group consisting of metallic oxides, e.g., antimony trioxide, copper oxide, magnesium oxide, zinc oxide, molybdenum oxide, iron oxide, manganese oxide, aluminum oxide, tin oxide, titanium oxide, and nickel oxide, carbonates, e.g., calcium carbonate and barium carbonate, metaborates, e.g., zinc metaborate and barium metaborate, melamine derivatives, e.g., melamine, melamine cyanurate, methylolmeramine, (iso)cyanuric acid, melam, melem, mellon, succinoguanamine, melamine sulfate, acetoguanamine sulfate, melam sulfate, guanylmelamine sulfate, melamine resin, BT resin, cyanuric acid, isocyanuric acid, isocyanuric acid derivatives, melamine isocyanurate, benzoguanamine, and acetoguanamine, guanidine compounds, silicone compounds, and phosphorus base flame retardants, may be listed. Among these, the phosphorus base flame retardants are particularly preferable.

[0027] As the phosphorus base flame retardant, for example, at least one kind selected from the group consisting of triethyl phosphate, tricresyl phosphate, triphenyl phosphate, cresylphenyl phosphate, octyldiphenyl phosphate, diethylene-phosphoric acid ethyl ester, dihydroxypropylenephosphoric acid butyl ester, ethylenephosphoric acid disodium ester, methylphosphonate, dimethyl methylphosphonate, diethyl methylphosphonate, ethyl phosphonate, propyl phosphonate, butyl phosphonate, 2-methyl-propyl phosphonate, t-butyl phosphonate, 2,3-dimethylbutyl phosphonate, octyl phosphonate, phenyl phosphonate, dioctylphenyl phosphonate, dimethyl phosphinate, methylethyl phosphinate, methylpropyl phosphinate, diethyl phosphinate, dioctyl phosphinate, phenyl phosphinate, diethylphenyl phosphinate, diphenyl phosphinate, bis(4-methoxyphenyl) phosphinate, red phosphorus, ammonium phosphate, ammonium polyphosphate, melamine phosphate, guanylurea phosphate, melamine polyphosphate, guanidine phosphate, ethylenediamine phosphate, phosphazene, and melamine methylphosphonate, is listed. Among these, red phosphorus, ammonium phosphate, ammonium polyphosphate, melamine phosphate, guanylurea phosphate, melamine polyphosphate, guanidine phosphate are preferably used.

[0028] Red phosphorus preferably has its surface modified by organic materials or/and inorganic materials. Red phosphorus surface treated by, for example, at least one or more of phenol resins, epoxy resins, ethylene-vinyl acetate copolymers, melamine-formaldehyde polycondensates, and hydroxides and oxides of Mg, Ca, Ti, Al, Co and Zr, may be mentioned, although it is not limited to these.

[0029] Blending ratios of these flame-retardant assistants are usually 0.1 to 10% by weight, preferably are 0.5 to 5% by weight in terms of flame retardant compositions.

[0030] The flame retardant composition according to the present invention can impart superior flame retardancy to various resins.

[0031] Next, a flame-retardant resin composition according to the present invention will be explained.

[0032] As a resin which can be used, although not specifically limited, for example, thermosetting resins, e.g., epoxy resins, phenol resins, polyurethane resins, melamine resins, urea resins, aniline resins, furan resins, alkyd resins, xylene resins, unsaturated polyester resins, and diaryl phthalate resins, polybutylene terephthalate resins, polyethylene terephthalate resins, polycarbonates, polyphenylene oxides, polyphenylene ethers, nylon 6, nylon 66, nylon 12, polyacetal, polyethylene, polypropylene, polybutadiene, polyacrylonitrile, polystyrene, polymethylmethacrylate, polyethylene oxides, polytetramethylene oxides, thermoplastic polyurethanes, phenoxy resins, polyamides, ethylene/propylene copolymers, ethylene/1-butene copolymers, ethylene/propylene/non-conjugate diene copolymers, ethylene/ethyl acrylate copolymers, ethylene/glycidyl methacrylate copolymers, ethylene/vinyl acetate/glycidyl methacrylate copolymers, ethylene/propylene-g-maleic anhydride copolymers, polyester polyether elastomer, polytetrafluoroethylene, and denatured materials thereof, are listed. These resins may be homopolymers, copolymers, or mixtures of at least two kinds.

[0033] Herein, thermosetting resin means a synthetic resin being cured to become semipermanently insoluble and infusible, wherein chemical changes due to the action of heat, catalysts, ultraviolet rays, etc., occur to develop cross-linking structure so as to increase molecular weight and to form a three-dimensional network structure. Thermoplastic resin means a resin that exhibits fluidity by heating so that shaping thereof is possible.

[0034] Blending ratios of the flame retardant compositions into various resins are 1 to 20 parts by weight, preferably 2 to 15 parts by weight in terms of P relative to 100 parts by weight of the resin. This is due to the fact that when the blending ratio is less than 1 part by weight, flame retarding effects are not sufficiently exhibited and on the other hand, when it is more than 20 parts by weight, it is not preferable since the mechanical properties of molded materials are likely to be degraded even though flame retarding effects are increased.

[0035] Furthermore, concurrent use with common additives, for example, antioxidants of phosphorus base, sulfur base, hindered phenol base, etc., thermal stabilizers, ultraviolet absorbers, lubricants, release agents, dyes, colorants containing pigments, cross-linking agents, softeners, and dispersing agents, as another component blended into resins, is possible.

[0036] When necessary, stiffness of the resin can be increased to a great degree by addition of fibrous and/or granular fillers. As such a filler, for example, glass fibers, carbon fibers, metallic fibers, aramid resins, asbestos, potassium titanate whiskers, wollastonite, glass flakes, glass beads, talc, mica, clay, calcium carbonate, calcium silicate, barium sulfate, titanium oxide, fused silica, crystalline silica, magnesia, and aluminum oxide, are listed.

[0037] The flame retardant composition according to the present invention can be contained in various resins by normal publicly known methods. For example, in thermosetting resins, the method of concurrently blending the flame retardant composition of the present invention with a thermosetting resin and other additives, and the method of blending a thermosetting resin with a kind of resin components blended beforehand with the flame retardant composition of the present invention, may be mentioned. In thermoplastic resins, the method of fusing and blending the flame retardant composition of the present invention with an extruder, or the method of uniformly and mechanically blending granular materials all together, and thereafter molding by an extruder concurrently with blending, etc., are listed.

[0038] The flame retardant composition according to the present invention does not generate a halide gas during combustion while it maintains the inherent mechanical properties of the resin. Therefore, as a very safe plastic material, the flame retardant composition can be used for a broad use of purposes, for example, electric components, e.g., semiconductor sealing materials, laminated plates, connectors, switches, case members, transformer members, and coil bobbins, building materials, transportation equipment, e.g., automobiles, packages, and housefurnishings. In particular, flame-retardant epoxy resins are useful for semiconductor sealing materials.

[0039] As the epoxy resins useful for semiconductor sealing materials, monomers having at least two epoxy groups in a molecule, oligomer, and polymers in general, for example, bisphenol A type epoxy, bisphenol F type epoxy, bisphenol S type epoxy, phenol novolac type epoxy, cresol novolac type epoxy, naphthalene type epoxy, biphenyl type epoxy, aromatic amine, and N-glycidyl compounds derived from heterocyclic nitrogen base, e.g., N,N-diglycidylaniline, triglycidyl-isocyanurate, N,N,N',N'-tetraglycidyl-bis(p-aminophenyl)-methane, may be listed, although not specifically limited thereto. These may be used in combination of some kinds.

[0040] As a curing agent, every publicly known agent in the related art can be used. In particular, C<sub>2</sub> to C<sub>20</sub> straight chain aliphatic diamines, for example, ethylenediamine, trimethylenediamine, tetramethylenediamine, and hexamethylenediamine, amines, for example, metaphenylenediamine, paraphenylenediamine, paraxylenediamine, 4,4'-diaminodiphenylmethane, 4,4'-diaminodiphenylpropane, 4,4'-diaminodiphenylether, 4,4'-diaminodiphenylsulfone, 4,4'-diaminodicyclohexane, bis(4-aminophenyl)phenylmethane, 1,5-diaminonaphthalene, metaxylenediamine, paraxylenediamine, 1,1-bis(4-aminophenyl)cyclohexane, and dicyanodiamide, novolac type phenol resins, for example, phenol novolac resins, cresol novolac resins, tert-butylphenol novolac resins, and nonylphenol novolac resins, resol

type phenol resins, polyoxystyrenes, for example, polyparaoxystyrenes, phenol resins obtained by copolycondensation of phenolic compounds, in which hydrogen atoms bonded to aromatic rings such as a benzene ring and a naphthalene ring are substituted by hydroxyl groups, and carbonyl compounds, and acid anhydrides, are listed as examples, although not specifically limited to these.

[0041] As the filler, fused silica powders, crystalline silica powders, alumina, silicon nitride, etc., are listed. Blending ratios of these fillers are 60 to 90% by weight in resin compositions. When necessary, by using additives publicly known in the related art, for example, release agents, e.g., natural wax, synthetic wax, metallic salts of straight chain aliphatic acids, acid amides, esters, and paraffin, colorants, e.g., carbon black and red iron oxide, and various curing accelerators, it is possible to be used as resin compositions for sealing, and preferably be used for sealing semiconductors by transfer molding, injection molding, etc.

## EXAMPLES

[0042] The present invention will be explained below in detail using examples, although the present invention is not limited to these.

### <Preparation of nitrilotris(methylene)phosphonic acid salt>

Sample A; nitrilotris(methylene)phosphonic acid-3Mg·1H<sub>2</sub>O salt

[0043] 11 L of water and 1304.6 g (13.50 mol) of magnesium carbonate were put in 15 L stainless container and were agitated (a state of slurry). The resulting slurry was heated to 80°C, and thereafter, 2720.9 g (4.55 mol) of nitrilotris(methylene)phosphonic acid (hereafter abbreviated as NTP) (50% aqueous solution) was added dropwise. After the dropping was completed, the agitation was continued at 80°C until the pH of the reaction solution became 6. Then, the resulting solution was centrifugally filtered to produce white crystals.

[0044] These crystals were dried at 110°C for 24 hours and further at 250°C for 24 hours, and were pulverized by a mixer to produce 1598.4 g of objective material. The yield was 92.3% (yield relative to NTP).

[0045] The resulting white crystals were dissolved into hydrochloric acid, and contents of P and Mg were measured by ICP. As a consequence, the concentration of P was 23.62% and that of Mg was 19.24%.

Sample B; nitrilotris(methylene)phosphonic acid-3Ca·4H<sub>2</sub>O salt

[0046] 11 L of water and 1373.0 g (13.64 mol) of calcium carbonate were put in 15 L stainless container and were agitated (a state of slurry). The resulting slurry was heated to 80°C, and thereafter, 2720.9 g (4.55 mol) of NTP (50% aqueous solution) was added dropwise. After the dropping was completed, the agitation was continued at 80°C until pH of the reaction solution became constant (about 2.2). Then, the resulting solution was centrifugally filtered to produce white crystals.

[0047] These crystals were dried at 110°C for 24 hours and further at 250°C for 24 hours, and were pulverized by a mixer to produce 1983.3 g of objective material. The yield was 94.3% (v.s. NTP).

[0048] The resulting white crystals were dissolved into hydrochloric acid, and contents of P and Ca were measured by ICP. As a consequence, the concentration of P was 19.76% and that of Ca was 26.93%.

Sample C; nitrilotris(methylene)phosphonic acid-3Zn·8H<sub>2</sub>O salt

[0049] 5 L of water and 826.85 g (12.60 mol) of potassium hydroxide were put in 15 L stainless container and were agitated. 1256.19 g (2.10 mol) of NTP (50% aqueous solution) was added dropwise thereto so as to produce an aqueous solution of NTP-K salt.

[0050] Separately, 7 L of water and zinc sulfate·7H<sub>2</sub>O were put in 18 L stainless container and were agitated. The aforementioned aqueous solution of NTP-K salt was added dropwise thereto. After the dropping was completed, the agitation was continued at room temperature until the pH of the reaction solution became constant (about 6.2). Then, the resulting solution was centrifugally filtered to produce white crystals.

[0051] These crystals were dried at 110°C for 24 hours and further at 250°C for 24 hours, and were pulverized by a mixer to produce 1153.8 g of objective material. The yield was 86.7% (v.s. NTP).

[0052] The resulting white crystals were dissolved into hydrochloric acid, and concentrations of P and Zn were measured by ICP. As a consequence, the concentration of P was 15.18% and that of Zn was 27.65%.

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## EXAMPLES 1 to 3 and COMPARATIVE EXAMPLES 1 to 3

[0053] Various additives were added to ethylene ethylacrylate resin in the blending ratios (parts by weight) as shown in Table 1, and the resulting resin was kneaded by heated roll set at 120 to 130°C for 5 to 10 minutes. Sheets 3 mm in thickness were formed using a heating press at a molding pressure of 150 kg/cm<sup>2</sup>, at a pressing time of 5 minutes, and at a die temperature of 115°C, and furthermore, test pieces 125 mm in length and 13 mm in width were formed.

<Flame retardancy test>

[0054] In flame retardancy tests, resins processed into 125 mm in length x 13 mm in width x 3 mm in thick sheets, prepared as described above, were tested according to vertical combustion-firing test of materials classified under UL94 (94V-0, 94V-1, and 94V-2). The results thereof are shown in Table 3. Pass or fail criteria in UL94 are as shown in Table 2.

Table 1

(part by weight)						
	Example			Comparable Example		
	1	2	3	1	2	3
Ethylene/ethyl acrylate resin	100	100	100	100	100	100
Mg(OH) <sub>2</sub>	80	80	80	80		
Red phosphorus					10	
Ammonium polyphosphae						35
Sample A (P content)	41 (10)					
Sample B (Pcontent)		53 (10)				
Sample C (Pcontent)			68 (10)			

Table 2

		94V-0	94V-1	94V-2
Test 1	Time of remaining flame	≦ 10 sec	≦ 30 sec	≦ 30 sec
Test 2	Sum of time of remaining flame for 10 times ignition	≦ 50sec	≦ 250sec	≦ 250sec
Test 3	Presence of remaining flame or ember which reached a cramp	none	none	none
Test4	Presence of flame drop which ignite cotton 300 mm below	none	none	none
Test 5	Time of remaining ember after removal of second igniter	≦ 30sec	≦ 60sec	≦ 60 sec

Table 3

	Example			Comparative Example		
	1	2	3	1	2 3	
Test 1 (sec)	1 5	0	1 5	>30	>30	>30
Test2 (sec)	2 2 0	2 0	222	>250	>250	>250
Test 3	none	none	none	Yes	Yes	Yes
Test4	none	none	none	none	none	none
Test 5 (sec)	2 0	4	2 5	-	-	-

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Table 3 (continued)

	Example			Comparative Example		
	1	2	3	1	2 3	
Pass or Failure of UL94	V-1	V-0	V-1	Failure	Failure	Failure

EXAMPLES 4 to 6 and COMPARATIVE EXAMPLES 4 and 5

**[0055]** Various additives were blended to novolac resin, prepared with the ratio of formaldehyde/phenol being 0.9 on a mole basis, in the blending ratios shown in Table 4, and the resulting resin was kneaded by heated roll set at 80 to 90°C for 5 minutes. After pulverization, molded materials having predetermined shapes were formed using a universal press at a molding pressure of 250 kg/cm<sup>2</sup>, for a pressing time of 60 seconds, and at a die temperature of 150°C.

**[0056]** Flame retardancy tests were evaluated in a manner similar to that in EXAMPLES 1 to 3. Furthermore, the presence or absence of phosphine gas during molding, and surface properties of the molded materials are shown in Table 5.

**[0057]** Red phosphorus was used after the surface thereof was modified by a phenol resin.

Table 4

(part by weight)					
	Example			Comparative Example	
	4	5	6	4	5
Novolac resin	100	100	100	100	100
Hexamethylene tetramine	15	15	15	15	15
Al(OH) <sub>3</sub>	40	40	40	40	40
Sample A (Pcontent)	41 (10)				
Sample B (Pcontent)		53 (10)			
Sample C (Pcontent)			68 (10)		
Red phosphorus				10	
Ca borate					10

Table 5

	U L 94	Surface	Generation of PH <sub>3</sub> during molding
Example 4	V - 0	good	none
Example 5	V - 0	good	none
Example 6	V - 0	good	none
Comp. Exam.4	V-0	good	yes
Comp. Exam. 5	V - 0	rough	none

(Note 1) Generation of phosphine gas (PH<sub>3</sub>) was determined by a detector tube method.

None: less than 0.15 ppm Yes: 0.15 ppm or more (Note 2) Surface property was determined by touch.

**[0058]** From the results as shown in Table 5, the phenol resins containing the flame retardant compositions according to the present invention are superior in flame retardancy, the surfaces of the molded materials are smooth, and furthermore, no generation of phosphine gas was recognized during molding. On the other hand, although, the one containing calcium borate also exhibited superior flame retardancy, the surface of the molded material was rough. The one containing red phosphorus also exhibited superior flame retardancy, but the generation of phosphine gas was



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recognized during processing. EXAMPLES 7 to 9 and COMPARATIVE EXAMPLES 6 and 7

[0059] Various additives were blended to bisphenol A diglycidylether type epoxy resins in the blending ratios as shown in Table 6. These were poured into molds having predetermined shapes and were cured at 105°C for 10 hours.

[0060] Flammability of each sample based on UL94 and generation or no generation of phosphine gas during molding were determined. The results thereof are shown in Table 7. Red phosphorus was used after the surface thereof was modified by a phenol resin.

Table 6

(part by weight)					
	Example			Comp. Example	
	7	8	9	6	7
Epoxy resin	100	100	100	100	100
TMHPA*	80	80	80	80	80
Benzyl dimethyl amine	1	1	1	1	1
Mg(OH) <sub>2</sub>	80	100	100		
Sample A (Pcontent)	41 (10)				
Sample B (Pcontent)		53 (10)			
Sample C (Pcontent)			68 (10)		
Hydrated alumina				25	
Red phosphorus					25

(Note) TMHPA: tetramethylhexahydrophthalic anhydride

Table 7

	UL 94	Generation of PH <sub>3</sub> during molding
Example 7	V - 0	none
Example 8	V - 0	none
Example 9	V - 0	none
Comp. Exam. 6	failure	none
Comp. Exam. 7	failure	yes

## EXAMPLES 10 to 15

[0061] Various additives were blended to various resins as shown in Table 8. Test pieces for a tensile test according to ATSM D-638 were prepared by a 30 mm diameter axis extruder and injection molding. Then, strength and elongation were measured according to JIS K-7113.

[0062] Test pieces for evaluation of flame retardancy based on UL94 were prepared in a manner similar to that in the above description, and flammability was measured. The results thereof are shown in Table 9.

[0063] Red phosphorus was used after the surface thereof was modified by aluminum hydroxide and titanium hydroxide.

[0064] Conditions for melting extrusion, pellet drying, and injection molding of each resin are described below.

Polybutylene terephthalate (hereafter abbreviated as PBT)

extrusion; 250 to 290°C / 150 rpm

drying; 110°C / 12 hours

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molding; 250 to 290°C / die 80°C

## Nylon 6

extrusion; 250 to 300°C / 150 rpm  
drying; 100°C / 24 hours  
molding; 250 to 300°C / die 80°C

## Polycarbonate

extrusion; 260 to 320°C / 75 rpm  
drying; 120°C / 12 hours  
molding; 260 to 320°C / die 110°C

Table 8

(part by weight)						
Thermoplastic resin			Me-phosphonate sample		Mg(OH) <sub>2</sub>	Red phosphorus
Example	kind	part	kind	part (Pcontent)	part	part
10	PBT	100	A	41 (10)	80	
11	PBT	100	A	41 (10)	80	1
12	Nylon 6	100	B	53 (10)	80	
13	Nylon 6	100	B	53 (10)	80	1
14	Polycarbonate	100	C	68 (10)	80	
15	Polycarbonate	100	C	68 (10)	80	1

Table 9

Example	U L 94	Mechanical properties	
		Strength (kgf/cm <sup>2</sup> )	Elongation (%)
10	V-1	542	66
11	V-0	539	63
12	V-1	780	162
13	V-0	775	160
14	V-1	654	118
15	V-0	650	115

EXAMPLES 16 to 19 and COMPARATIVE EXAMPLES 8 and 9

[0065] Various additives were added to polypropylene resin (hereafter abbreviated as PP) in the blending ratios as shown in Table 10, and the resulting resin was kneaded by heated roll set at 230°C for 5 minutes. Melting extrusion was performed at a screw revolution of 87 rpm. Then, test pieces based on UL94 were prepared by injection molding (cylinder temperature: 230°C, die temperature 50°C).

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[0066] As tin oxide hydrate,  $\text{SnO} \cdot \text{H}_2\text{O}$  was used, and as zinc borate,  $2\text{ZnO} \cdot 3\text{B}_2\text{O}_3 \cdot 3.5\text{H}_2\text{O}$  was used.

Table 10

(Part by weight)						
	Example				Comp. Example	
	16	17	18	19	8	9
P Presin	100	100	100	100	100	100
Sample A (P content)	41 (10)		41 (10)	41 (10)		
Sample B (P content)		53 (10)				
Hydrated SnO		80			80	
Zn-borate	80		20	20		80
Ammonium polyphosphate				1		
Pass or Failure of U L 94	V - 0	V - 0	V - 1	V - 0	Failure	Failure

EXAMPLES 20 to 22 and COMPARATIVE EXAMPLES 10 and 11

[0067] Various additives were added to a mixture of poly(2,6-dimethyl-1,4-phenylene) oxide and polystyrene (hereafter abbreviated as PPO) in blending ratios as shown in Table 11, and the resulting mixture was kneaded by heated roll set at 240 to 310°C for 5 minutes. Melting extrusion was performed at a screw revolution of 40 to 100 rpm. The resulting pellets were dried at 110°C for 4 hours, and thereafter, test pieces based on UL94 were prepared by injection molding (cylinder temperature: 240 to 310°C, die temperature 90 °C).

[0068] As borax,  $\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_5 \cdot 5\text{H}_2\text{O}$  was used, and as hydrotalcite,  $\text{Mg}_6\text{Al}_2(\text{OH})_{16}\text{CO}_3 \cdot 4\text{H}_2\text{O}$  was used.

Table 11

(Part by weight)					
	Example			Comp. Example	
	20	21	22	11	12
P Po resin	100	100	100	100	100
Sample A (P content)	41 (10)				
Sample B (P content)		53 (10)	53 (10)		
Borax	80			80	
hydrotalcite		20	20		80
Melamine polyphosphate			1		
Pass or Failure of U L 94	V - 0	V - 1	V - 0	Failure	Failure

EXAMPLES 23 and 24 and COMPARATIVE EXAMPLE 13

[0069] Various additives were added so as to become compositions as shown in Table 12, and were mixed at ordinary temperature by a mixer. Then, the resulting compositions were kneaded at 70 to 100°C by a two-roll mill, and were pulverized after cooling so as to produce molding materials. The resulting molding materials were tableted. Test pieces based on UL94 were prepared by a low pressure transfer molding machine under conditions of 175°C, 70 kg/cm<sup>2</sup>, and 120 seconds, and flame retardancy tests based on UL94 were performed. Chips of 3 by 6 mm were sealed in 16pSOS for solder humidity tests, and the sealed test elements were subjected to solder humidity tests. The results thereof are shown in Table 12.

## &lt;Solder humidity test&gt;

[0070] The sealed test elements were treated in an environment of 85°C and 85% RH for 72 hours, and thereafter, were immersed in a solder bath at 260°C for 10 seconds. Then, pressure cooker tests (125°C and 100% RH) were performed. Failures in opening of circuits were measured and the time of the first occurrence of failure was taken as moisture resistance of solder.

Table 12

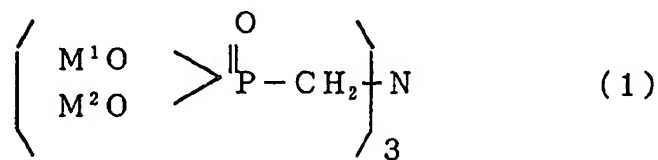
(Part by weight)			
	Example		Comp. Example
	23	24	13
Orthocresolnovolac type epoxy resin	100		
Bisphenol type epoxy resin		100	100
Phenolnovolac resin curing agent	52.74	53.4	58.2
Fused silica powder	186.8	344.8	388
Spherical silica powder	192.3	344.8	383.2
Carbon black	2.74	4.3	4.85
Carnauba wax	2.74	4.3	4.85
Triphenyl phosphine	1.1	1.7	1.9
Sample B (P content)	12.2 (2.3)	24.3 (4.6)	
Sb <sub>2</sub> O <sub>3</sub>			14.6
Brominated epoxy resin			14.6
UL94	V-0	V-0	V-0
Solder humidity	500	500	500

Industrial Applicability

[0071] As described above, since the flame retardant composition according to the present invention can impart superior flame retardancy to various resins while maintaining the inherent mechanical properties of the resins, has a smoke suppression properties, and emits no irritating odor, the composition has great value when used as a non-halogen base flame retardant.

**Claims**

1. A flame retardant composition, comprising a nitrilotris(methylene)phosphonic acid metallic salt produced by reacting nitrilotris(methylene)phosphonic acid represented by the following general formula (1):



(wherein M<sup>1</sup> and M<sup>2</sup> represent a hydrogen atom or an alkaline-earth metal.) and a salt thereof with a divalent metallic compound.

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2. A flame retardant composition according to Claim 1, wherein said nitrilotris(methylene)phosphonic acid metallic salt is a hydrate.
3. A flame retardant composition according to Claim 1 or Claim 2, comprising the nitrilotris(methylene)phosphonic acid metallic salt and a hydrated metallic compound.
4. A flame retardant composition according to Claim 3, further comprising a flame-retardant assistant.
5. A flame retardant composition according to Claim 4, wherein said flame-retardant assistant is a phosphorus base flame retardant.
6. A flame retardant composition according to Claim 5, wherein said phosphorus base flame retardant is at least one kind selected from the group consisting of red phosphorus, ammonium phosphate, ammonium polyphosphate, melamine phosphate, guanidurea phosphate, melamine polyphosphate, and guanidine phosphate.
7. A flame-retardant resin composition, comprising a flame retardant composition according to one of Claims 1 to 6.
8. An epoxy resin composition, comprising a flame retardant composition according to one of Claims 1 to 6.

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP99/04524

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> Int.Cl. <sup>6</sup> C09K21/12, C08K5/5317, 5/51, 3/22, 3/32, C08L101/00, C08L63/00 According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b> Minimum documentation searched (classification system followed by classification symbols) Int.Cl. <sup>6</sup> C09K21/12, C08K5/5317, 5/51, 3/22, 3/32, C08L101/00, C08L63/00 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) CA (STN), REGISTRY (STN)		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP, 5-4997, A (Jouhoku Kagaku Kougyou K.K.), 14 January, 1993 (14. 01. 93) (Family: none)	1-8
Y	JP, 63-22866, A (CIBA-Geigy AG.), 30 January, 1988 (30. 01. 88) & EP, 245207, A2	1-8
Y	JP, 2-180875, A (CIBA-Geigy AG.), 13 July, 1990 (13. 07. 90) & EP, 363321, A2 & US, 5093494, A & DE 68910776, T2	1-8
Y	JP, 55-5979, A (Hoechst AG.), 17 January, 1980 (17. 01. 80) & EP, 6568, A1 & DE, 2827867, A1	1-8
Y	JP, 4-178440, A (Nippon Petrochemicals Co., Ltd.), 25 June, 1992 (25. 06. 92) (Family: none)	3-8
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 29 October, 1999 (29. 10. 99)		Date of mailing of the international search report 9 November, 1999 (09. 11. 99)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.		Authorized officer Telephone No.

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